Fossil Dinoflagellate Taxa by Chinese Authors, 1978-1984

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FOSSIL DINOFLAGELLATE TAXA BY CHINESE AUTHORS, 1978-1984

by

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ABSTRACT

Chen, Y.Y., Harland, R., Stover, L.E. and Williams, G.L., 1988. Fossil dinoflagellate taxa by Chinese authors, 1978-1984. Can. Tech. Rep. of Hydrogr. and Ocean Sci. No. 103: iv + 40 p.

This paper presents the results of a systematic analysis of twenty-two organic-walled microplankton genera described by Chinese authors between 1978 and 1984, and identified initially as fossil dinoflagellates. Of the twenty-two genera, we recognize nine as valid dinoflagellate genera (*Apiculadinium, Bellatudinium, Bohaidina, Bosedinia, Lacunodinium, Parabohaidina, Pseudokomewuia, Spiniferopsis* and *Suibindia*) and emend one of them (*Bosedinia*); treat six as junior synonyms (*Bipolaribucina, Hashenia, Paraireiana, Sanshuia, Sinocysta* and *Stomodinium*); acknowledge *Bosea* He Cheng-quan and Qian Ze-shu (1979) as a junior homonym of *Bosea* Srivastava (1975); and consider five genera as belonging to the Acritarcha (*Conicoidium, Mirificysta, Paucibucina, Prominangularia* and *Tetranguladinium*). We do not provide a detailed analysis for *Pseudostephodinium* because of insufficient information.

RÉSUMÉ

Chen, Y.Y., Harland, R., Stover, L.E. and Williams, G.L., 1988. Fossil dinoflagellate taxa by Chinese authors, 1978-1984. Can. Tech. Rep. of Hydrogr. and Ocean Sci. No. 103: iv + 40 p.

L'article présente les résultats de l'analyse systématique de vingt-deux genres de microplancton à thèque organique décrits par des auteurs chinois entre 1978 et 1984 et d'abord reconnus comme des dinoflagellés fossiles. Parmi les vingt-deux genres, neuf sont reconnus comme des genres de dinoflagellés valides (*Apiculadinium, Bellatudinium, Bohaidina, Bosedinia, Lacunodinium, Parabohaidina, Pseudokomewuia, Spiniferopsis* et *Suibindia*) et l'un d'eux a été corrigé (*Bosedinia*); six sont considérés comme de nouveaux synonymes (*Bipolaribucina, Hashenia, Paraireiana, Sanshuia, Sinocysta* et *Stomodinium*); *Bosea* He Cheng-quan et Qian Ze-shu (1979) est reconnu comme un nouvel homonyme de *Bosea* Srivastava (1975); enfin cinq genres sont considérés comme appartenant aux Acritarcha (*Conicoidium, Mirificysta, Paucibucina, Prominangularia* et *Tetranguladinium*). À cause d'un manque d'information, le cas de *Pseudostephodinium* n'a pas été analysé en détail.

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INTRODUCTION

Palynological research, like many other branches of science in the Peoples' Republic of China, has increased substantially since the end of 1976. Between 1978 and 1984, several publications on microplankton identified as fossil dinoflagellates from marine to nonmarine depositional environments have appeared (He Cheng-quan, 1980, 1984a, 1984b; He Cheng-quan and Qian Ze-shu 1979; Sung Zhi-chen *et al.*, 1978; Yu Jingxian, 1982; Yu Jingxian *et al.*, 1981; Yu Jingxian *et al.*, 1983 and Yu Jingxian and Zhang Wangping, 1980). These papers contain descriptions, illustrations and stratigraphic data on twenty-two new genera, to which seventy-six species have been assigned. The majority of these publications are written almost entirely in Chinese; however, many have English summaries and a few provide generic descriptions in both Chinese and English.

The generic discussions which we present in this paper are based on the English translations by Y. Y. Chen of the generic and specific descriptions, together with selected critical passages from the publications by Chinese authors listed above. In addition we had English translations of the generic descriptions in Sung Zhi-chen, *et al.* (1978) and in Yu Jingxian *et al.* (1981) prepared by Mao Shaozhi and edited by R. A. Fensome. As with many translations, subjective interpretations are unavoidable when ambiguities occur in the original text. Despite such shortcomings, considerable effort was made to honor the intent and meaning of the original descriptions and to reconcile the text with the illustrative material. In addition to providing English analyses, we also include new illustrations for each of the retained dinoflagellate genera.

BACKGROUND

The first genera of fossil dinoflagellates described by Chinese authors in the review period are *Bipolaribucina*, *Bohaidina*, *Conicoidium*, *Parabohaidina*, *Paucibucina*, and *Prominangularia*, which were proposed by Sung Zhi-chen *et al.*, (1978). This publication was referenced as Jiabo (1978) in Lentin and Williams (1981, 1985). We believe the citation should be Sung Zhi-chen *et al.*, 1978 and accordingly, have cited it as such throughout this publication.

In the next two years, three additional genera were described: *Bosea* in 1979 by He Cheng-quan and Qian Ze-shu, *Hashenia* in 1980 by Yu Jingxian and Zhang Wangping and *Pseudokomewuia* by He Cheng-quan, also in 1980. In the ensuing three years, Yu Jingxian alone and in conjunction with others introduced the following seven genera: *Apiculadinium*, *Bellatudinium*, *Pseudostephodinium*, *Sanshuia* (Yu Jingxian *et al.* 1981), *Mirificysta*, *Suibindia* (Yu Jingxian 1982) and *Tetranguladinium* (Yu Jingxian *et al.* 1983). The last six genera were presented by He Cheng-quan in 1984. These are *Lacunodinium*, *Paraireiana*, *Sinocysta*, *Spiniferopsis*, *Stomodinium* (all 1984a) and *Bosedinia* (1984b).

SUMMARY

The results of the analyses of the twenty-two genera are summarized below.

1. The nine taxa retained as valid dinoflagellate genera are: *Apiculadinium*, *Bellatudinium*, *Bohaidina*, *Bosedinia*, *Lacunodinium*, *Parabohaidina*, *Pseudokomewuia*, *Spiniferopsis* and *Suibindia*. Of these only *Bosedinia* is emended.

2. Six taxa are treated as junior synonyms of previously established dinoflagellate genera. These genera and their senior synonyms are: *Bipolaribucina*, synonym of *Distatodinium*; *Hashenia*, synonym of *Canningia*; *Paraireiana*, synonym of *Carpatella*; *Sanshuia*, synonym of *Geiselodinium*; *Sinocysta*, synonym of *Laciniadinium* and *Stomodinium*, synonym of *Xenicodinium*.

3. He Cheng-quan (1984b) noted that *Bosea* is a junior homonym of *Bosea* Srivastava (1975). Accordingly, he proposed the substitute name *Bosedinia*, which is discussed under 1.

4. *Conicoidium*, *Mirificysta*, *Paucibucina*, *Prominangularia* and *Tetranguladinium* are considered as belonging in the Acritarcha.

5. We had insufficient data to provide a detailed analysis of *Pseudostephodinium*.

FORMAT

Presentation of the genera is alphabetical and the format for the discussion is essentially that introduced by Stover and Evitt (1978), with the following modifications. For the retained dinoflagellate genera: (1) the original and other published descriptions are placed at the end of the individual analyses, rather than at their beginnings; (2) line drawings are included with the descriptions; (3) in the MODIFIED DESCRIPTION, the order of the headings PARATABULATION and ARCHEOPYLE are reversed; (4) under SPECIES, citations to the holotypes of the type species are now included, as well as complete citations for all accepted and reattributed species; and (5) the category GEOGRAPHIC DISTRIBUTION AND AGE has been added where appropriate. Original descriptions are provided for all twenty-two genera, regardless of their eventual assignment.

DISCUSSION OF GENERA

GENUS *APICULADINIUM* Yu Jingxian *et al.* 1981, p. 261
Figure 1A-B

SYNOPSIS

Cysts proximate, outline ovate to roughly triangular; epicyst longer than hypocyst; endophragm and periphragm separated apically and antapically, appressed elsewhere; surface ornamented with features of low relief, and also with fine folds; paratabulation indicated by paracingulum only; archeopyle not discernible.

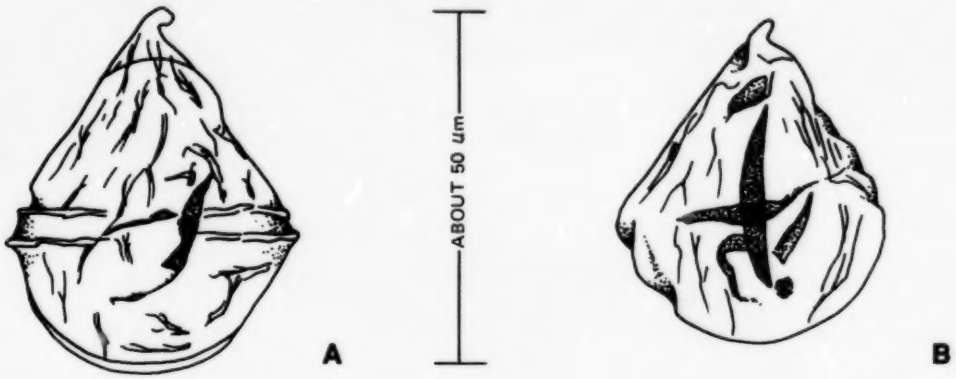


Figure 1A-B. *Apiculadinium.* Drawings based on illustrations in Yu Jingxian *et al.* (1981), especially pl. 1, figs. 19 and 32, respectively.

MODIFIED DESCRIPTION

Shape. Roundly conical to pear-shaped or ovoidal; epicyst conical, outline more or less triangular, longer than hypocyst; latter hemispherical. Apical horn may be present, antapical horns lacking.

Wall Relationships. Endophragm and periphragm separated slightly apically and antapically, appressed elsewhere.

Wall Features. Surface granulate and finely folded.

Archeopyle. Not discernible.

Paratabulation. Expressed by paracingulum only.

Paracingulum. Expressed by transverse folds.

Parasulcus. Not indicated.

Size. Small to intermediate, about 40 μm to 60 μm in length.

COMPARISON

According to Yu Jingxian *et al.* (1981, p. 261), *Apiculadinium* differs from *Laciniadinium* McIntyre 1975 in having an indiscernible rather than a combined intercalary and precingular archeopyle, and from *Hebecysta* Bujak and Fisher 1976 in not having an intercalary archeopyle. Perhaps a somewhat closer comparison can be made, for example, between *Apiculadinium* and *Geiselodinium* Krutzsch 1962 or *Subtilisphaera* Jain and Millepied 1973, which either lack an archeopyle, or have an inconsistently developed archeopyle. In general, the epipericoels and hypopericoels on *Geiselodinium* and *Subtilisphaera* are more prominent than those on *Apiculadinium*.

SPECIES (Monotypic)

Type Species:

Apiculadinium ovatum Yu Jingxian *et al.* 1981, p. 262, pl. 1, figs. 19, 28, 32, 35-37. Holotype: pl. 1, fig. 36.

GEOGRAPHIC DISTRIBUTION AND AGE

Guangdong Province, China; Late Cretaceous (undifferentiated).

ORIGINAL DESCRIPTION (Translation)

Cysts proximate, roundly conical to pear-shaped or ovoidal. Epicyst outline triangular with an apical horn; hypocyst more or less hemispherical, smaller than epicyst, without antapical horns, but a short baculate spine may occur at the antapex. Wall thin, endophragm and periphragm separated only at the apex and antapex, appressed elsewhere. Surface granulate and ornamented with numerous, irregular folds. Paratabulation indicated by paracingulum only, which is prominent, planar or slightly helicoidal. Archeopyle not discernible. (Translated from Yu Jingxian *et al.*, 1981, p. 261).

GENUS *BELLATUDINIUM* Yu Jingxian *et al.* 1981, p. 261

Figure 2

SYNOPSIS

Cysts proximate, peridinioid; outline pentagonal to pear-shaped; epicyst longer than hypocyst and with or without a prominent apical horn; antapical horns present; autophragm thin and ornamented with irregular features of low relief; paratabulation reflected by paracingulum and parasulcus; archeopyle not discernible.

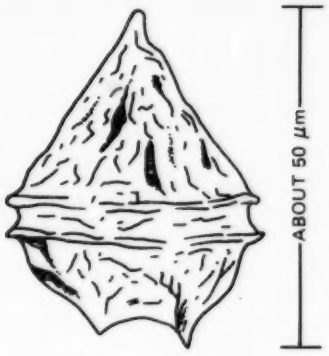


Figure 2. *Bellatudinium.* Drawing based on illustrations in Yu Jingxian *et al.* (1981), pl. 1, figs. 20-22 and 24.

MODIFIED DESCRIPTION

Shape. Peridinioid, outline pentagonal to pear-shaped; epicyst widely to narrowly triangular and with or without a prominent apical horn; antapical horns strongly or weakly developed.

Wall Relationships. Autophragm only.

Wall Features. Surface finely and irregularly folded.

Archeopyle. Not discernible.

Paratabulation. Expressed by paracingulum and parasulcus.

Paracingulum. Stated as being wide and planar; evidently indicated by transverse folds.

Parasulcus. Stated as extending onto the epicyst, mode of expression not indicated.

Size. Small to intermediate, about 40 μm to 60 μm in length.

COMPARISON

According to Yu Jingxian *et al.* (1981, p. 261), *Bellatudinium* differs from *Palaeoperidinium* Deflandre 1935 emended Sarjeant 1967 in lacking an archeopyle and in having the parasulcus developed on the epicyst. The latter is of questionable value as a generic taxonomic character. Evidently, *Bellatudinium* differs from *Apiculadinium* Yu Jingxian *et al.* 1981 in having only one wall layer rather than two.

COMMENT

The recognition of *Apiculadinium* and *Bellatudinium* as separate genera is based on the generic descriptions, not on the illustrations. In our opinion, the illustrated specimens of *Apiculadinium* and *Bellatudinium* are virtually indistinguishable and those of the former are not clearly cavate. If our interpretation is correct, the two genera are synonymous.

SPECIES

Type Species:

Bellatudinium conspicuum Yu Jingxian *et al.* 1981, p. 261, pl. 1, figs. 20-22, 24, text-fig.22. Holotype: pl. 1, fig. 20.

Other Accepted Species:

Bellatudinium fusum Yu Jingxian *et al.* 1981, p. 261, pl. 1, figs. 25-27, 29-31. Holotype: pl. 1, fig. 27.

GEOGRAPHIC DISTRIBUTION AND AGE

Guangdong Province, China; Late Cretaceous (undifferentiated).

ORIGINAL DESCRIPTION (Translation)

Cysts proximate, outline pentagonal to pear-shaped with a bent epicyst. Epicyst larger than hypocyst. An apical horn is present and may or may not be prominent. Two unequal antapical horns are strongly or weakly developed. Autophragm thin, ornamented with numerous, fine, irregular folds. Paratabulation indicated by the paracingulum, which is wide and planar, and by the parasulcus, which extends onto the epicyst. Archeopyle not discernible. (Translated from Yu Jingxian *et al.*, 1981, p. 261).

GENUS *BIPOLARIBUCINA* Sung Zhi-chen *et al.* 1978, p. 57 *ex* Lentin and Williams 1981, p. 28

SENIOR SYNONYM

Distatodinium Eaton 1976, p. 262-263; synonymy proposed herein.

ORIGINAL DESCRIPTION (Translation)

Cysts chorate, ellipsoidal or ovoidal in shape, wall thin; surface smooth or scabrate. Processes, which are distributed mainly in the polar region and are sparse or absent in the equatorial area, are tubular and open, or closed distally, or nontabular and furcate. Number of processes varies, usually 10-15. Paratabulation uncertain; archeopyle possibly apical. (Translated from Sung Zhi-chen *et al.* 1978, p. 57).

COMMENTS

When Sung Zhi-chen *et al.* (1978) proposed *Bipolaribucina*, they obviously intended to establish *Hystrichosphaeridium paradoxum* Brosius 1963 as its type species. However, they failed to give a complete citation and make reference to the basionym. These omissions were rectified when Lentin and Williams (1981, p. 28) provided a full and direct reference for the type species.

The generic description of *Bipolaribucina* accords unfavorably with the morphology of its type species and the other species of *Bipolaribucina* show little resemblance to *Hystrichosphaeridium paradoxum*. Moreover, uncertainties remain about the archeopyle and the exact nature of the processes on the species of *Bipolaribucina* proposed by Sung Zhi-chen *et al.* (1978). Pending re-examination of all these species, we prefer to: (1) reject the transfer of *Hystrichosphaeridium paradoxum* to *Bipolaribucina* and retain the species in *Distatodinium* Eaton 1976 (its last previous assignment), thereby making *Bipolaribucina* a junior synonym of *Distatodinium*; and (2) transfer the remaining species of *Bipolaribucina* to *Impletosphaeridium* Morgenroth 1966.

SPECIES

Reattributed Species:

Bipolaribucina conicosa Sung Zhi-chen *et al.* 1978, p. 57, pl. 29, figs. 4-5 = *Impletosphaeridium conicosum* (Sung Zhi-chen *et al.* 1978) *comb. nov.* Holotype: pl. 29, fig. 4.

B. huanghuaensis Sung Zhi-chen *et al.* 1978, p. 57, pl. 29, figs. 9-10 = *Impletosphaeridium huanghuaense* (Sung Zhi-chen *et al.* 1978) *comb. nov.* Holotype: pl. 29, fig. 9.

B. liaoningensis Sung Zhi-chen *et al.* 1978, p. 58, pl. 29, figs. 6-8 = *Impletosphaeridium liaoningense* (Sung Zhi-chen *et al.* 1978) *comb. nov.* Holotype: pl. 29, fig. 7.

B. oblongata Sung Zhi-chen *et al.* 1978, p. 58, pl. 29, figs. 1-3 = *Impletosphaeridium oblongatum* (Sung Zhi-chen *et al.* 1978) *comb. nov.* Holotype: pl. 29, fig. 2.

B. paradoxa (Brosius 1963, p. 41, pl. 4, fig. 1, 6; text-fig.22, no.11a-c) Sung Zhi-chen *et al.* 1978, p. 58 *ex* Lentin and Williams, 1981, p. 28 = *Distatodinium paradoxum* (Brosius 1963) Eaton 1976, p. 265. Holotype: pl. 4, fig. 6 in Brosius, 1963. By implication, *B. paradoxa* was the type species of the genus *Bipolaribucina*.

B. tianjinensis Sung Zhi-chen *et al.* 1978, p. 59, pl. 29, figs. 13-14 = *Impletosphaeridium tianjinense* Sung Zhi-chen *et al.* 1978) *comb. nov.* Holotype: pl. 29, fig. 13.

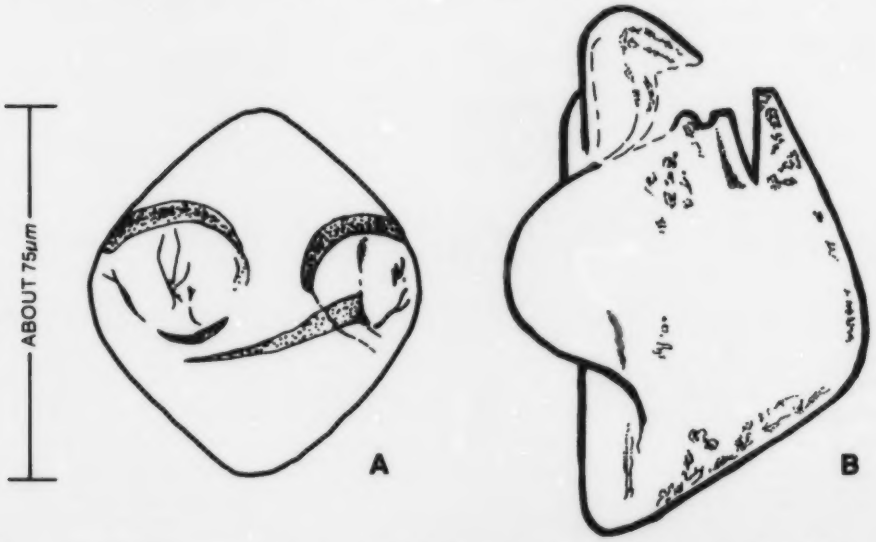
GEOGRAPHIC DISTRIBUTION AND AGE

Coastal Bohai Bay area in Liaoning, Hebei and Shandong Provinces, China; Paleogene (Oligocene).

GENUS *BOHAIDINA* Sung Zhi-chen *et al.* 1978, p. 37-38
Figures 3A-B

SYNOPSIS

Cysts proximate, outline in dorsal-ventral view rhombic to roundly quadrangular; a ventral boss-like feature is present near both equatorial-lateral margins; autophragm with features of low relief; no indications of paraplates; archeopyle type uncertain.



Figures 3A-B. *Bohaidina.* Drawing A based mainly on pl. 12, fig. 7 in Sung Zhi-chen *et al.* (1978); drawing B based on fig. 1 in Mao Shaozhi (1986).

MODIFIED DESCRIPTION

Shape. Rhomboidal to roundly quadrangular in outline.

Wall Relationships. Autophragm only.

Wall Features. Surface variously ornamented with features of low relief; one or two conspicuous, generally equatorial folds may be present and two boss-like features occur near both equatorial lateral margins.

Archeopyle. Type uncertain, apparently variable; see comment below.

Paratabulation. None indicated.

Paracingulum. Generally not indicated.

Parasulcus. Not indicated.

Size. Intermediate, about 50 μm to 80 μm in length.

COMMENT

Sung Zhi-chen *et al.* (1978) stated in their discussion that the archeopyle type is uncertain because among their specimens some archeopyles appear to be apical, some combined apical and intercalary, some precingular, and still other openings are evidently only tears. They further remarked that because the archeopyle type is a significant character in classifying fossil dinoflagellates, it is entirely possible that the group could subsequently be subdivided after a careful study of its archeopyle types. For the present, *Bohaidina* includes species with different types of archeopyles.

To Sung Zhi-chen *et al.* (1978), the dorsal-ventrally compressed body (ventrally convex, dorsally concave) suggested that *Bohaidina* probably is related to the Dinophyceae. The genus has many characteristics of fossil Dinophyceae such as apical pores, apical protrusions, archeopyles and paracingula: some specimens have a paracingular zone (delineated by folds), two ventral prominences and a depressed transverse area indicating a paracingulum. Thus, *Bohaidina* is considered to belongs to the Dinophyceae rather than the Acritarcha.

According to Mao Shaozhi (1986) and based on information supplied to her by Xu Jinli, the archeopyle in *Bohaidina* is Aa + 3I. Evidence for the combination apical and intercalary archeopyle is presented by Figure 1 of Mao Shaozhi (1986), a representation of which is our Figure 3B. The opening could be an archeopyle, but it could just as easily be a simple rupture positioned so that it simulates an archeopyle in this one example. One of us (R.H.) examined specimens of *Bohaidina* (and of *Parabohaidina*) from the Bohai Gulf and was unable to identify an archeopyle.

COMPARISON

Sung Zhi-chen *et al.* (1978) indicated that *Bohaidina* differs from *Parabohaidina* Sung Zhi-chen *et al.* 1978 in having prominences in the equatorial ventral area; *Parabohaidina* lacks such prominences. Among the genera of fossil dinoflagellates whose shapes are similar to those of *Bohaidina*, some are cavate and each has only one type of archeopyle. Such genera include *Komewuia*, Cookson and Eisenack 1960b emended Chen 1982 and *Rhombodinium* Gocht 1955 emended Bujak 1979.

SPECIES

Type Species:

Bohaidina laevigate Sung Zhi-chen *et al.* 1978, p. 38-39, pl. 13, figs. 1-3; pl. 14, figs. 1-10. Holotype: pl. 13, fig. 1.

subsp. *biconica* Sung Zhi-chen *et al.* 1978, p. 38, pl. 13, fig. 3.

subsp. *laevigata* Sung Zhi-chen *et al.* 1978, p. 38, pl. 13, fig. 1-2; pl. 14, figs. 7-10.

subsp. *minor* Sung Zhi-chen *et al.* 1978, p. 38-39, pl. 14, figs. 1-6.

Other Accepted Species:

Bohaidina apicornicula Sung Zhi-chen *et al.* 1978, p. 39, pl. 8, fig. 7. Holotype: None designated; only one specimen illustrated.

B. asymmetrosa Sung Zhi-chen *et al.* 1978, p. 39, pl. 9, fig. 2. Holotype: None designated; only one specimen illustrated.

B. fusiforma Sung Zhi-chen *et al.* 1978, p. 39-40, pl. 8, fig. 6. Holotype: None designated; only one specimen illustrated.

B. granulata Sung Zhi-chen *et al.* 1978, p. 40-41, pl. 8, fig. 8; pl. 11, figs. 1-3, 5; pl. 12, figs. 1-8; pl. 13, figs. 4-9. Holotype: pl. 12, fig. 8.

subsp. *biconica* Sung Zhi-chen *et al.* 1978, p. 49, pl. 12, fig. 1, 4; pl. 13, fig. 4-9.

subsp. *granulata* Sung Zhi-chen *et al.* 1978, p. 40, pl. 12, figs. 2-3, 5-8.

subsp. *minor* Sung Zhi-chen *et al.* 1978, p. 40-41, pl. 11, fig. 1-3.

B. microreticulata Sung Zhi-chen *et al.* 1978, p. 41, pl. 10, figs. 1-8b. Holotype: pl. 10, fig. 2.

B. retirugosa Sung Zhi-chen *et al.* 1978, p. 41, pl. 7, figs. 7-11; pl. 8, figs. 1-5; pl. 9, figs. 3-9; pl. 10, figs. 9-10; pl. 11, figs. 7-12. Holotype: pl. 9, fig. 8.

subsp. *brachorhombica* Sung Zhi-chen *et al.* 1978, p. 41-42, pl. 10, fig. 9-10.

subsp. *minor* Sung Zhi-chen *et al.* 1978, p. 42, pl. 11, fig. 7-12.

subsp. *retirugosa* Sung Zhi-chen *et al.* 1978, p. 41, pl. 7, figs. 7-11; pl. 8, figs. 1-5; pl. 9, figs. 3-9.

B. rivularisa Sung Zhi-chen *et al.* 1978, p. 42, pl. 11, fig. 4. Holotype: None designated; only one specimen illustrated.

B. rugosa Sung Zhi-chen *et al.* 1978, p. 42, pl. 9, fig. 1. Holotype: None designated; only one specimen illustrated.

Provisionally Accepted Species:

B. dorsiprominentis Sung Zhi-chen *et al* 1978, p. 39, pl. 15, figs. 1a-3c - shape differs from that of other species in the genus. Holotype: pl. 15, fig. 1a-e.

GEOGRAPHIC DISTRIBUTION AND AGE

Coastal Bohai Bay area in Liaoning, Hebei and Shandong Provinces, China; Paleogene (Late Eocene and Oligocene).

ORIGINAL DESCRIPTION (Translation)

Cysts proximate, without an endocyst, rhomboidal, ovoidal or roundly quadrangular in outline. Apical, antapical and lateral horns are not evident and indications of a paracingulum and parasulcus are generally absent. However, one or two, possibly secondarily-developed folds occur in the equatorial area. A prominence is present at both ends of the folds on the ventral side. Ornamentation is variable, of low relief, and processes are not present. Archeopyle type uncertain. (Translated from Sung Zhi-chen *et al.* 1978, p. 37).

GENUS *BOSEA* He Cheng-quan and Qian Ze-shu 1979, p. 177-178

SENIOR HOMONYM

Bosea Srivastava 1975, p. 19 - a plant microfossil genus. The microplankton treated under the name *Bosea* were transferred to *Bosedinia* by He Cheng-quan 1984b.

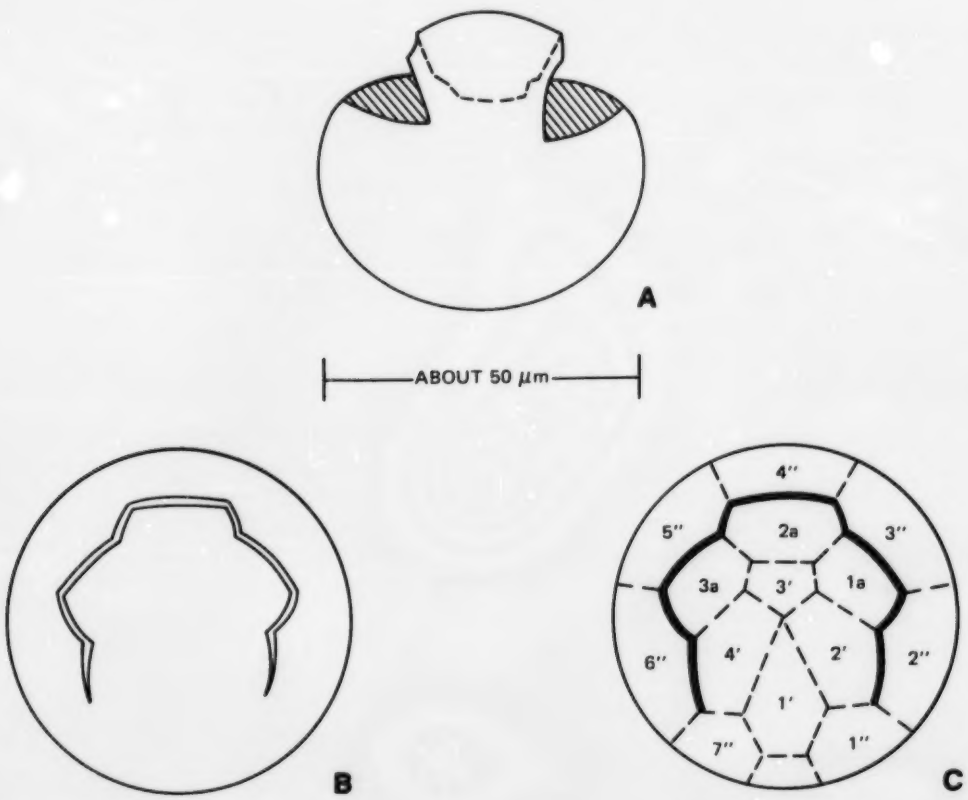
ORIGINAL DESCRIPTION

The original description of *Bosea* is given under *Bosedinia*.

GENUS *BOSEDINIA* He Cheng-quan 1984b, p. 172 emended herein
Figures 4A-C

SYNOPSIS

Cysts proximate, subspherical, autophragm smooth or ornamented with features of low relief; indications of paratabulation absent except for archeopyle sutures which follow the adcingular margins of paraplates 2', 1a-3a and 4'; opercular flap evidently composed of paraplates 1'-4' and 1a-3a, wide area of attachment.



Figures 4A-C. *Bosedinia*. A. - drawing of ventral view based on unpublished data; B. - schematic representation of primary archeopyle suture; C. - probable epicystal paratabulation.

EMENDED DESCRIPTION

Shape. Subspherical, but may be modified by folding.

Wall Relationships. Autophragm only.

Wall Features. Structures expressive of paratabulation absent; wall smooth or uniformly ornamented with features of low relief.

Archeopyle. Combined apical and intercalary, type [tAtI]a, archeopyle suture, which fails to close upon itself, follows the posterior margins of paraplates 2', 1a-3a, and 4'; operculum composed of four apical and three intercalary paraplates; operculum normally adnate with a wide area of attachment.

Paratabulation. Expressed by archeopyle or opercular margin on epicyst only; formulae probably peridiniacean: 4', 3a, 7".

Paracingulum. Not indicated.

Parasulcus. Not indicated.

Size. Small to intermediate, about 35 μm to 60 μm in diameter.

COMMENTS AND COMPARISON

In the original description (as *Bosea*), He Cheng-quan and Qian Ze-shu (1979) were uncertain about the archeopyle and stated that it was indicated by a circular opening and was perhaps of the epicystal type. Later, He Cheng-quan (1984b, p. 172-173) reasoned that the archeopyle on *Bosedinia* was not apical because it lacked the characteristic zigzag margin and accessory sutures and the opening was also too large. On the other hand, He Cheng-quan believed that it was too small to be epicystal and, therefore, the opening represented a transitional archeopyle type which was termed "subepicystal."

Our observations support those of He Cheng-quan (1984b). Furthermore, a detailed examination of more than 50 specimens by one of the authors (YYC) demonstrated that the archeopyle margin is as shown in Figure 4B. The adnate operculum is composed of paraplates 1'-4' and 1a-3a (see Figure 4C). This interpretation is based entirely on the archeopyle and opercular outlines since individual paraplates are not delineated on the operculum or elsewhere on the cysts.

Thus, the operculum on *Bosedinia* is similar to that of *Ascodinium* Cookson and Eisenack 1960a emended Helenes 1983. However, the operculum on *Bosedinia* has an exceptionally wide zone of attachment, whereas on *Ascodinium* the attachment area is narrow. Moreover, the operculum is free on the majority of cavate *Ascodinium* specimens. The wide attachment zone on *Bosedinia* results because the sutures between 1" and 1' + 2' and between 7" and 1' + 4' (present in *Ascodinium*) fail to develop. Other features which serve to distinguish the two genera include the more or less varied shapes of *Ascodinium* and its more complex wall relationships and layering.

SPECIES

Type Species:

Bosedinia granulata (He Cheng-quan and Qian Ze-shu 1979, p. 178, pl. 1, figs. 1-5) He Cheng-quan 1984b, p. 172. Holotype, pl. 1, fig. 2.

Other Accepted Species:

Bosedinia granorugosa (He Cheng-quan and Qian Ze-shu 1979, p. 178-179, pl. 1, figs. 12-13) He Cheng-quan 1984b, p. 172. Holotype: pl. 1, fig. 13.

B. hepuensis He Cheng-quan 1984b, p. 173-174, pl. 8, figs. 9-11. Holotype: pl. 8, fig. 10.

B. infragranulata He Cheng-quan 1984b, p. 174, pl. 6, figs. 17-23. Holotype: pl. 6, fig. 17.

B. laevigata (Sung Zhi-chen *et al.* 1978, p. 126-127, pl. 32, fig. 23) He Cheng-quan 1984b, p. 174. Holotype: None designated; only one specimen illustrated.

B. micirugosa He Cheng-quan 1984b, p. 174-175, pl. 7, figs. 16-20; pl. 8, figs. 6-8. Holotype: pl. 7, fig. 16,

subsp. *micirugosa* He Cheng-quan 1984b, p. 174-175, pl. 7, figs. 16-20.

subsp. *minor* He Cheng-quan 1984b, p. 175, pl. 8, figs. 6-8.

B. operculata (Sung Zhi-chen *et al.* 1978, p. 107, pl. 40, figs. 17-20; pl. 48, figs. 3a-b) He Cheng-quan 1984b, p. 175. Holotype: pl. 40, fig. 19.

B. radiata He Cheng-quan 1984b, p. 176, pl. 8, fig. 23. Holotype: pl. 8, fig. 23.

B. retirugosa He Cheng-quan 1984b, p. 175, pl. 8, figs. 1-4. Holotype: pl. 8, fig. 4.

B. sinensis He Cheng-quan 1984b, p. 176, pl. 7, figs. 9-13. Holotype: pl. 7, fig. 12.

B. tuberculata He Cheng-quan 1984b, p. 176, pl. 6, fig. 24. Holotype: pl. 6, fig. 24.

B. verrurugosa He Cheng-quan 1984b, p. 176-177, pl. 8, fig. 5. Holotype: pl. 8, fig. 5.

GEOGRAPHIC DISTRIBUTION AND AGE

Guangxi Province and Coastal Bohai Bay area in Liaoning, Hebei and Shandong Provinces, China; Paleogene (Late Eocene and Oligocene).

ORIGINAL DESCRIPTION (Translation)

Cysts proximate, spherical to subovoidal. Apical and antapical horns absent. Paracingulum, parasulcus and paratabulation not shown.

Archeopyle indicated by a "circular opening," perhaps of the epicystal type, generally located at the widest part of the body. Operculum adnate or free. Hypocyst larger than epicyst. Surface smooth, scabrate, or rugulate; no spine-like processes. (Translated from He Cheng-quan and Qian Ze-shu 1979, p. 179).

GENUS *CONICOIDIUM* Sung Zhi-chen *et al.* 1978, p. 45

ORIGINAL DESCRIPTION (Translation)

Cysts broadly conical, outline oblately quadrangular to subtriangular. There are one or two folds in the equatorial area, but no indications of equatorial prominences, a paracingulum, a parasulcus, an archeopyle, or an endocyst. Nor is there usually an apical protrusion. Surface smooth, granulate, rugulate or tuberculate, variable from species to species. A nucleus-like spot is often visible. (Translated from Sung Zhi-chen *et al.* 1978, p. 45).

COMMENT

Features indicative of dinoflagellate affinity such as the archeopyle, paracingulum, parasulcus, or peridinioid outline, are lacking in this genus. Therefore, we regard it as an acritarch.

SPECIES

Type Species:

Conicoidium tuberculatum Sung Zhi-chen *et al.* 1978, p. 46, pl. 18, figs. 5-10; text-fig. 7. Holotype: pl. 18, fig. 7.

Other Accepted Species:

Conicoidium granorugosum Sung Zhi-chen *et al.* 1978, p. 46, pl. 18, figs. 11-12. Holotype: pl. 18, fig. 12.

C. granulatum He Cheng-quan 1984b, p. 156-157, pl. 2, figs. 22-27, text-fig. 1. Holotype: pl. 2, fig. 26.

C. laevigatum Sung Zhi-chen *et al.* 1978, p. 46, pl. 18, fig. 1. Holotype: None designated; only one specimen illustrated.

GEOGRAPHIC DISTRIBUTION AND AGE

Coastal Bohai Bay area in Liaoning, Hebei and Shandong Provinces, China; Paleogene (Oligocene).

GENUS *HASHENIA* Yu Jingxian and Zhang Wangping 1980, p. 107

SENIOR SYNONYM

Canningia Cookson and Eisenack 1960b emended Below 1981, synonymy proposed herein.

ORIGINAL DESCRIPTION (Translation)

Cysts 4 to 6-sided in outline, endocyst enclosed by a periphragm which is 3 um to 4 um wide, paracingulum discernible, a weakly developed apical horn is present. Archeopyle apical - translated from Yu Jingxian and Zhang Wangping (1980, p. 107).

SPECIES (Monotypic)

Reattributed Species:

Hashenia reticulata Yu Jingxian and Zhang Wangping 1980, p. 107, pl. 1, fig. 17; pl. 2, figs. 1-2 = *Canningia xinjiangensis* (Yu Jingxian and Zhang Wangping 1980) *nom. subst. pro.* Holotype: pl. 2, fig. 1. With the transfer of *Hashenia reticulata* to *Canningia*, the species becomes a junior homonym of *C. reticulata* Cookson and Eisenack 1960b, the type species of *Canningia*. Therefore, we propose *C. xinjiangensis* as a substitute name for the species from China, whose type specimens are from Xinjiang Province, China. The range of the species is Late Cretaceous (Maastrichtian).

COMMENTS

The description of this monotypic genus, together with the illustration of the holotype (Yu Jingxian and Zhang Wangping, 1980, pl. 2, fig. 1), lead us to believe that *Hashenia* and *Canningia* are congeneric. According to Yu Jingxian and Zhang Wangping (1980), the range of *Hashenia* is Late Cretaceous (Turonian to Maastrichtian). Therefore, recognition of *Hashenia* as a junior synonym of *Canningia* extends the Last Appearance Datum of the latter genus from the base of the Campanian into the Maastrichtian.

GENUS *LACUNODINIUM* He Cheng-quan 1984a, p. 768

Figure 5

SYNOPSIS

Cysts proximate, subspherical to broadly ellipsoidal, surface pitted to microreticulate, paratabulation expressed solely by precingular type P archeopyle, operculum free.

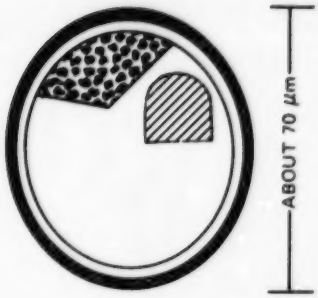


Figure 5. *Lacunodinium.* Drawing based on specimen illustrated in He Cheng-quan (1984a), pl. 1, fig. 2. Surface ornamentation depicted in insert.

MODIFIED DESCRIPTION

Shape. Subspherical to broadly ellipsoidal.

Wall Relationships. Wall composed of appressed periphragm and endophragm.

Wall Features. Surface finely pitted (punctate) to microreticulate.

Archeopyle. Precingular, type P, (3" only); operculum free.

Paratabulation. Indicated by archeopyle only.

Paracingulum. Not indicated.

Parasulcus. Not indicated.

Size. Intermediate, about 70 µm long and 55 µm to 65 µm wide.

COMPARISON

Lacunodinium differs from the following genera, all of which have type P (3") precingular archeopyles, in being finely pitted to microreticulate; *Pyxidinopsis* Habib 1976 is imperfectly reticulate, *Tectatodinium* Wall 1967 is thick walled and has a smooth or faintly ornamented outer surface. *Cerebrocysta* Bujak in Bujak *et al.* 1980 has interspersed short, discontinuous ridges and granules, *Operculodinium* Wall 1967 is spinate, *Chytroeisphaeridia* (Sarjeant 1962) Downie and Sarjeant 1965 emended Davey 1979 is thin walled and smooth or scabrate, and *Filisphaera* Bujak 1984 has a periphragm composed of radiating fibers.

SPECIES (Monotypic)

Type Species:

Lacunodinium foveolatum He Cheng-quan 1984a, p. 768, pl. 1, figs. 2a-b, 3. Holotype: pl. 1, figs. 2a-b.

GEOGRAPHIC DISTRIBUTION AND AGE

West Talimu (Tarim) Basin, Xinjiang Province, China; Paleogene (Middle Eocene).

ORIGINAL DESCRIPTION

"Proximate dinoflagellate cysts, subspherical or elliptical in shape, without apical and antapical horns. Cingulum and sulcus lacking. Cyst wall thick, composed of appressed periphragm and endophragm. Surface foveolate. Paratabulation indicated only by archeopyle. Archeopyle precingular, Type P (3" only); operculum free". (From He Cheng-quan 1984a, p. 772).

GENUS *MIRIFICYSTA* Yu Jingxian 1982, p. 237 (English translation, p. 262)

ORIGINAL DESCRIPTION

"Proximate cysts having ellipsoidal ambitus with an apical horn marked with a slit, antapex broadly rounded; cyst wall single layered, scabrate or irregularly lined on its surface. Sometimes on the position of the paracingulum the cyst is prolonged to form a less [small?] prominence, which may be [a] paracingulum. Reflected paratabulation and archeopyle is absent". (From Yu Jingxian 1982, p. 262).

COMMENTS

The bizarre shape of this microfossil and its lack of explicit features clearly indicative of dinoflagellate affinity, lead us to regard *Mirificysta* as an acritarch.

SPECIES (Monotypic)

Type Species:

Mirificysta lineata Yu Jingxian 1982, p. 238, pl. 1, fig. 20, text-fig. 3. Holotype: pl. 1, fig. 20.

GEOGRAPHIC DISTRIBUTION AND AGE

Heilongjian Province, China; Late Jurassic to Early Cretaceous.

GENUS *PARABOHAIDINA* Sung Zhi-chen *et al.* 1978, p. 43 emended He Cheng-quan 1984b, p. 155

Figure 6

SYNOPSIS

Cysts proximate, outline subcircular to roundly lozenge-shaped; folds generally present ventrally, ventral prominences absent; autophragm variously ornamented with features of low relief; archeopyle, when present, apical.

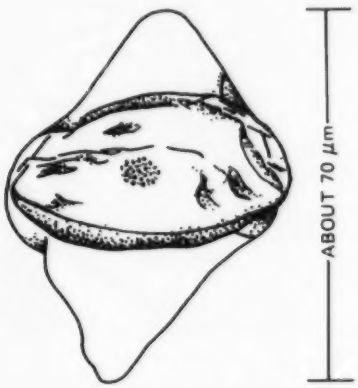


Figure 6. *Parabohaidina*. Drawing based on specimen illustrated in Sung Zhi-chen *et al.* (1978), pl. 16, fig. 1.

MODIFIED DESCRIPTION

Shape. Outline subcircular, rhombic, to roundly lozenge-shaped.

Wall Relationships. Autophragm only.

Wall Features. Surface variously ornamented with features of low relief; ventral folds usually present; ventral prominences absent.

Archeopyle. Apical, when discernible; specific type unknown.

Paratabulation. Not indicated.

Paracingulum. Not indicated.

Parasulcus. Not indicated.

Size. Small to intermediate, about 35 µm to 80 µm in length and width.

COMPARISON

Sung Zhi-chen *et al.* (1978) stated that *Parabohaidina* differs from *Bohaidina* Sung Zhi-chen *et al.* 1978 in lacking ventral prominences.

SPECIES

Type Species:

Parabohaidina laevigata Sung Zhi-chen *et al.* 1978, p. 44, pl. 15, fig. 4; pl. 16, figs. 1-11; pl. 17, figs. 1-3. Holotype: pl. 16, fig. 9.

subsp. *laevigata* Sung Zhi-chen *et al.* 1978, p. 44, pl. 16, figs. 7-11.

subsp. *minor* Sung Zhi-chen *et al.*1978, p. 44, pl. 16, figs. 1-6; po. 17, figs. 1-3.

subsp. *ovata* Sung Zhi-chen *et al.* 1978, p. 44, pl. 15, fig. 4.

Other Accepted Species:

Parabohaidina granulata Sung Zhi-chen *et al.* 1978, p. 44, pl. 17, figs. 4-6. Holotype: pl. 17, fig. 5.

P. operculata He Cheng-quan 1984b, p. 155-156, pl. 1, figs. 19-20. Holotype: pl. 1, fig. 20.

P. retirugosa Sung Zhi-chen *et al.* 1978, p. 44-45, pl. 17, figs. 7-9. Holotype: pl. 17, fig. 7.

P. shangsica He Cheng-quan 1984b, p. 156, pl. 1, figs. 1-3. Holotype: pl. 1, fig. 1.

P. tuberculata He Cheng-quan 1984b, p. 156, pl. 1, fig. 9. Holotype: None designated; only one specimen illustrated.

P. verrucosa Sung Zhi-chen *et al.* 1978, p. 45, pl. 17, fig. 10. Holotype: None designated; only one specimen illustrated.

P. verrurugosa Sung Zhi-chen *et al.* 1978, p. 45, pl. 17, fig. 10. Holotype: None designated; only one specimen illustrated.

GEOGRAPHIC DISTRIBUTION AND AGE

Coastal Bohai Bay area in Liaoning, Hebei and Shandong Provinces and in Guangxi Province, China; Paleogene (Oligocene).

ORIGINAL DESCRIPTION (Translation)

Cysts subrhomboidal. Without indications of paracingulum, parasulcus, and endocyst. An equatorial, folded area, present on the ventral surface, is without prominences. Epicyst and hypocyst are about equal in size. Surface smooth, granulate, reticulate, rugulate or verrucate. (Translated from Sung Zhi-chen *et al*. 1978, p. 43).

EMENDED DESCRIPTION (Translation)

Cysts rhomboidal. Paracingulum, parasulcus, and endocyst all absent. Commonly there are two folds in the equatorial area, which are perhaps the expression of a paracingulum. Epicyst and hypocyst of equal size. There are no prominences at the ends of the equatorial area. Surface smooth, granulate, reticulate or verrucate. Archeopyle, when present, apical. (Translated from He Cheng-quan 1984b, p. 155).

GENUS *PARAIREIANA* He Cheng-quan 1984a, p. 768-769 (English Translation, p. 772-773)

SENIOR SYNONYM

Carpatella Grigorovich 1969, p. 74, synonymy proposed herein.

ORIGINAL DESCRIPTION

"Cysts proximate. Body subspherical with single apical and antapical horns, without processes and usually lacking paracingulum. Surface smooth of low relief (such as granula, rugae, and arched ridges). Paratabulation indicated only by archeopyle. Archeopyle precingular (3" only). Operculum free". (From He Cheng-quan 1984a, p. 773).

COMMENT

The description of *Paraireiana* He Cheng-quan 1984a is compatible with that of *Carpatella* Grigorovich 1969 as presented in Stover and Evitt (1978, p. 144-145). Therefore, we propose the suppression of *Paraireiana* He Cheng-quan 1984a, p. 768-769.

SPECIES (Monotypic)

Reattributed Species:

Paraireiana sinensis He Cheng-quan 1984a, p. 769, pl. 1, figs. 8-11 = *Carpatella sinensis* (He Cheng-quan 1984a) *comb. nov.* Holotype: pl. 1, fig. 8.

GENUS *PAUCIBUCINA* Sung Zhi-chen *et al.* 1978, p. 73

ORIGINAL DESCRIPTION (Translation)

Cysts subspherical, more or less circular in outline. Wall is usually thin with a smooth surface. Generally 4 to 5 tubular processes are distributed uniformly, possibly equatorially. Also present are other types of processes which vary in number (commonly 5, total number of processes never exceeds 10). Paratabulation is unknown, although the 4 to 5 tubular processes may be cingular. There are no indications of an archeopyle. (Translated from Sung Zhi-chen *et al.* 1978, p. 73).

COMMENT

The absence of features indicative of dinoflagellate affinity leads us to regard this genus as an acritarch.

SPECIES

Type Species:

Paucibucina dongyingensis Sung Zhi-chen *et al.* 1978, p. 74, pl. 24, fig. 1, text-fig. 14. Holotype: None designated.

Other Accepted Species:

Paucibucina liaoningensis Sung Zhi-chen *et al.* 1978, p. 74, pl. 24, fig. 2. Holotype: None designated; only one specimen illustrated.

P. simplex Sung Zhi-chen *et al.* 1978, p. 74, pl. 24, figs. 3-4. Holotype: pl. 24, fig. 3.

GEOGRAPHIC DISTRIBUTION AND AGE

Coastal Bohai Bay area in Liaoning, Hebei and Shandong Provinces, China; Paleogene (Oligocene).

GENUS *PROMINANGULARIA* Sung Zhi-chen *et al.* 1978, p. 47

ORIGINAL DESCRIPTION (Translation)

Cysts conical, subtriangular to roundly triangular in outline with one or two folds in the equatorial area (frequently only one seen), and two prominences [out-bulgings] of which either or both may originate in the equatorial or gonal [?angular or corner] areas. No paracingulum, parasulcus or endocyst discernible. Surface smooth or ornamented with structures of low relief. Archeopyle type unknown, perhaps precingular. (Translated from Sung Zhi-chen *et al.* 1978, p. 47).

COMMENT

We regard this genus as an acritarch, because of the lack of any indications of paratabulation and the absence of an archeopyle, a paracingulum and a parasulcus.

SPECIES

Type Species:

Prominangularia granulata Sung Zhi-chen *et al.* 1978, p. 47-48, pl. 19, figs. 7-12, text-fig. 8. Holotype: pl. 19, fig. 7.

Other Accepted Species:

Prominangularia dongyingensis Sung Zhi-chen *et al.* 1978, p. 48, pl. 19, figs. 13-17. Holotype: pl. 19, fig. 14.

P. laevigata Sung Zhi-chen *et al.* 1978, p. 48, pl. 19, figs. 5-6. Holotype: pl. 19, fig. 6.

P. micirugosa He Cheng-quan 1984b, p. 158, pl. 2, figs. 12-17. Holotype: pl. 2, fig. 14.

GEOGRAPHIC DISTRIBUTION AND AGE

Coastal Bohai Bay area in Liaoning, Hebei and Shandong Provinces, China; Paleogene (Oligocene).

GENUS *PSEUDOKOMEWUIA* He Cheng-quan 1980*, p. 1

Figures 7A-B

SYNOPSIS

Cysts proximate, cornucavate, commonly folded; periphragm outline subcircular with an apical horn and may have an antapical horn as well; archeopyle apparently apical, operculum adnate; other indications of paratabulation absent.

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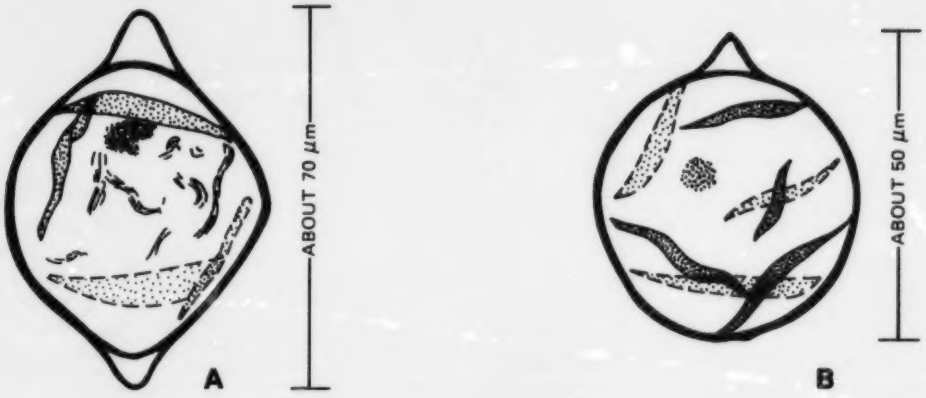
* Because this paper was distributed as a handout at the Fifth International Palynological Conference in 1980 at Cambridge, England, whether it is effectively published is doubtful. We include *Pseudokomewuia* simply for completeness.



Figures 7A–B. *Pseudokomewuia*. A. Drawing of *P.* (*Pseudokomewuia*). B. Drawing of *P.* (*Condocorpidia*). Drawings based on illustrations in He Cheng-quan (1980), pl. 1.

MODIFIED DESCRIPTION

Shape. Cyst outline essentially subcircular, apical horn present and an antapical horn may be present also; body possibly dorsoventrally compressed; horns generally short, inconspicuous to clearly evident.

Wall Relationships. Cornucavate.

Wall Features. Wall thin, commonly folded; surface smooth or ornamented with features of low relief.

Archeopyle. Stated as apical, operculum adnate; however, the trace of the archeopyle suture does not appear to be zigzag. The archeopyle might be combined apical and intercalary, perhaps similar to that of *Bosedinia* He Cheng-quan 1984b.

Paratabulation. Not indicated, except possibly by the archeopyle.

Paracingulum. Not indicated, unless transverse folds in the equatorial region reflect the paracingulum.

Parasulcus. Not indicated.

Size. Intermediate, about 50 µm to 75 µm in length and 45 µm to 55 µm in width.

COMPARISON

Pseudokomewuia differs from *Parabohaidina* Sung Zhi-chen *et al.* 1978 emended He Cheng-quan 1984b in being cavate. Other genera similar to *Pseudokomewuia* include *Komewuia* Cookson and Eisenack 1960b emended

Chen 1982 and *Apteodinium* Eisenack 1958, but these genera are acavate and possess precingular archeopyles. *Geiselodinium* Krutzsch 1962 is cornucavate, but has two antapical horns, generally a weakly, but clearly expressed paracingulum and no archeopyle. *Kalyptea* Cookson and Eisenack 1960b emended Wiggins 1975, *Netrelytron* Sarjeant 1961 emended Sarjeant 1966b and *Pareodinia* Deflandre 1947 emended Stover and Evitt 1978 all have intercalary archeopyles.

COMMENT

This genus has two subgenera: *Pseudokomewuia* (*Pseudokomewuia*), which contains forms with an antapical horn, and *Pseudokomewuia* (*Condocorpidia*), which includes forms without an antapical horn.

SPECIES

Type Species:

Pseudokomewuia (*Pseudokomewuia*) *laevigata* He Cheng-quan 1980, p. 2-3, pl. 1, figs.1-6, text-figs. 1-3. Holotype: pl. 1, fig. 1.

subsp. *fusiformis* He Cheng-quan 1984b, p. 165, pl. 3, figs. 5-9.

subsp. *laevigata* He Cheng-quan 1980, p.&2-3, pl. 1, figs. 1-6, text-figs. 1-3.

subsp. *subtilis* He Cheng-quan 1984b, p. 165, pl. 3, fig. 10-13, text-fig. 4.

Other Accepted Species:

Pseudokomewuia (*Pseudokomewuia*) *cerciata* He Cheng-quan 1980, p. 3-4, pl. 1, figs. 7-8. Holotype: pl. 1, fig. 7.

P. (*P.*) *granulata* He Cheng-quan 1980, p. 4, pl. 1, figs. 9-12. Holotype: pl. 1, fig. 10.

P. (*Condocorpidia*) *radiata* He Cheng-quan 1984b, p. 167, pl. 5, fig. 14. Holotype: pl. 5, fig. 14.

P. (*C.*) *retirugosa* He Cheng-quan 1980, p. 5-6, pl. 1, figs. 15-16. Holotype: pl. 1, fig. 16.

subsp. *pygmea* He Cheng-quan 1984b, p. 168, pl. 5, figs. 16-17, text-fig. 8.

subsp. *retirugosa* He Cheng-quan 1980, p. 5-6, pl. 1, figs. 15-16.

P. (C.) shangsica He Cheng-quan 1984b, p. 168-169, pl. 4, figs. 14-20; pl. 5, figs. 1-6; text-fig. 9. Holotype: pl. 4, fig. 14.

subsp. *pygmea* He Cheng-quan 1984b, p. 169, pl. 5, figs. 1-6.

subsp. *shangsica* He Cheng-quan 1984b, p. 168-169, pl. 4, figs. 14-20, text-fig. 9.

P. (C.) tuberculata He Cheng-quan 1984b, p. 169, pl. 5, fig. 15. Holotype: pl. 5, fig. 15.

P. (C.) unicornis He Cheng-quan 1980, p. 5, pl. 1, figs. 13-14, text-fig. 4. Holotype: pl. 1, fig. 14.

GEOGRAPHIC DISTRIBUTION AND AGE

Coastal region of Beibu Wan, Guangxi Province, China; Paleogene (Oligocene).

ORIGINAL DESCRIPTION

"Proximocavate dinoflagellate cysts, taroform, fusiform to rhomboidal in shape with one apical horn, with or without one antapical horn. No cingulum, sulcus and tabulation, but often having one or two transverse folds at equatorial area, which may be a reflection of the cingulum. Wall thin, surface smooth, granular, reticulo-rugose. Inner body present (or not evident), which lies closely under periphragm, deviating only at the bases of horns. Archeopyle, when present, apical. Operculum attached". (From He Cheng-quan 1980, p. 1).

GENUS *PSEUDOSTEPHODINIUM* Yu Jingxian *et al.* 1981, p. 262

ORIGINAL DESCRIPTION (Translation)

Cysts proximate, shape rhomboidal to pentagonal. Periphragm thin and appressed to endophragm, separated only at the apex. Surface ornamented with folds. Epicyst triangular in outline. Apical horn prominent, two antapical horns weakly developed. Paracingulum planar, indicated by ledge-like extension, 5-9 μm wide and reinforced with ribs or folds. Paratabulation uncertain. Archeopyle not discernible. (Translated from Yu Jingxian *et al.* 1981, p. 262).

COMMENTS

From an inspection of the photomicrographs and figures accompanying the description, the basis for several of the characteristics attributed to the genus is not clear. These characteristics include the apical cavation, the antapical horns, and the reinforced, wide cin-

gular structure. Further consideration of the genus is unwarranted until the uncertainties are clarified.

SPECIES (Monotypic)

Type Species:

Pseudostephodinium sanshuiense Yu Jingxian *et al.* 1981, p. 262, pl. 1, figs. 33-34, text-fig. 4. Holotype: pl. 1, fig. 34.

GEOGRAPHIC DISTRIBUTION AND AGE

Guangdong Province, China; Late Cretaceous (undifferentiated).

GENUS *SANSHUIA* Yu Jingxian *et al.* 1981, p. 259

SENIOR SYNONYM

Geiselodinium Krutzsch 1962, synonymy proposed herein.

ORIGINAL DESCRIPTION (Translation)

Cysts proximate, spherical, ellipsoidal to pentagonal in outline with one apical and two antapical horns. Periphragm and endophragm appressed, separated only in the areas of the apical and antapical horns (cornucavate), cysts have only one wall layer. Surface smooth, finely granulate or finely rugulate. Paratabulation indicated by paracingulum and parasulcus only, former planar, bordered by low ridges. Parasulcus, when present, extends onto the epicyst. Archeopyle unknown. (Translated from Yu Jingxian *et al.* 1981, p. 259).

COMMENTS

Comparison of the descriptions and illustrations of *Sanshuia* with those of *Geiselodinium* revealed no significant differences between the two genera. Accordingly, we consider them as congeneric and *Geiselodinium*, as the senior synonym, is retained.

SPECIES

Reattributed Species:

Sanshuia dalangshanensis Yu Jingxian *et al.* 1981, p. 259, pl. 1, figs. 7-10, 15-16 = *Geiselodinium dalangshanense* (Yu Jingxian *et al.* 1981) *comb. nov.* Holotype: pl. 1, fig. 7.

S. fibrirugularis Yu Jingxian *et al.* 1981, p. 260, pl. 1, figs. 11-12 = *Geiselodinium fibrirugulare* Yu Jingxian *et al.* 1981) *comb. nov.* Holotype: pl. 1, fig. 11.

S. micropoda Yu Jingxian *et al.* 1981, p. 259-260, pl. 1, figs. 3-4 = *Geiselodinium micropodum* (Yu Jingxian *et al.* 1981) *comb. nov.* Holotype: pl. 1, fig. 3.

S. minor Yu Jingxian *et al.* 1981, p. 260, pl. 1, figs. 13-14 = *Geiselodinium minor* (Yu Jingxian *et al.* 1981) *comb. nov.* Holotype: pl. 1, fig. 13.

Deflandrea minuta Sung Zhi-chen *et al.* 1978, p. 83, pl. 3, figs. 10-11 [basionym] = *Geiselodinium minutum* (Sung Zhi-chen *et al.* 1978) *comb. nov.* Holotype: pl. 3, fig. 11. Species validly transferred to *Sanshuia* by Lentin and Williams, 1985, p. 313.

D. ovata Sung Zhi-chen *et al.* 1978, p. 84, pl. 4, figs. 1-3 [basionym] = *Geiselodinium ovatum* (Sung Zhi-chen *et al.* 1978) *comb. nov.* Holotype: pl. 4, fig. 2. Species validly transferred to *Sanshuia* by Lentin and Williams, 1985, p. 313.

Sanshuia sphaerica Yu Jingxian *et al.* 1981, p. 259, pl. 1, figs. 1-2, 6 = *Geiselodinium sphaericum* (Yu Jingxian *et al.* 1981) *comb. nov.* Holotype: pl. 1, fig. 1. Former type species of *Sanshuia*.

GENUS *SINOCYSTA* He Cheng-quan 1984a, p. 769 (English translation, p. 773)

SENIOR SYNONYM

Laciniadinium McIntyre 1975, p. 70, synonymy proposed herein.

ORIGINAL DESCRIPTION

"Cysts proximate, compressed, roundly peridinioid to nearly subcircular in outline, an apical horn typically short and two antapical horns more or less reduced or absent. Wall thin and single-layered; surface smooth or granulate, striate and rugose. Paratabulation and inner body absent. Cingulum clearly indicated by low, parallel and transverse equatorial ridges. Sulcus often present. Archeopyle combination, Type tI3Pa, large and arched in outline, occupying most of the dorsal surface of the epicyst and involving an intercalary area (1a-3a) and three precingular paraplates (3"-5"). Operculum probably attached along its cingulum margin". (From He Cheng-quan 1984a, p. 773).

COMMENT

The description of *Sinocysta* is compatible with the original description of *Laciniadinium*, whose variability, as expressed by McIntyre (1975) and reiterated by Stover and Evitt (1978), readily encompasses the features attributed to *Sinocysta*.

SPECIES (Monotypic)

Reattributed Species:

Sinocysta minuta He Cheng-quan 1984a, p. 769-770, pl. 1, figs. 5-7, text-fig. 1 = *Laciniadinium minutum* (He Cheng-quan 1984a) *comb. nov.* Holotype: pl. 1, fig. 5.

GENUS *SPINIFERopsis* He Cheng-quan 1984a, p. 770
(English translation, p. 773-774)
Figure 8

SYNOPSIS

Cysts skolochorate, body subspherical with relatively few, solid, gonal processes along the paracingulum and near the antapical pole; paratabulation possibly gonyaulacalean, indicated by parasutural ridges and processes; archeopyle apical, operculum free.

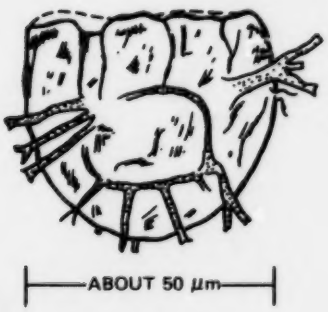


Figure 8. *Spiniferopsis.* Drawing based on specimen illustrated in He Cheng-quan (1984a), pl. 1, fig. 1.

MODIFIED DESCRIPTION

Shape. Body subspherical.

Wall Relationships. Periphragm and endophragm appressed.

Wall Features. Parasutural ridges low; gonal processes solid, distally simple or branched, relatively few, confined to the cingular area near the antapical end of cyst; surface between processes granular; intergonal processes absent.

Archeopyle. Apical, type [tA]; operculum free, but not observed.

Paratabulation. Indicated mainly by parasutural features, stated as gonyaulacacean, formula given as: ?', 0-1a, 6", 6c, 5-6"'?, ?p, 1""; presence of intercalary paraplates not evident.

Paracingulum. Apparently relatively narrow, planar or slightly helicoidal.

Parasulcus. Not indicated.

Size. Intermediate, 50 μm long (without operculum), 55 μm wide.

COMMENT

The genus is based on only one specimen.

COMPARISON

According to He Cheng-quan (1984a), *Spiniferopsis* differs from *Ctenidodinium* Deflandre 1938 emended Benson 1985 and from *Spiniferites* Mantell 1850 emended Sarjeant 1970 in possessing an apical archeopyle rather than an epicystal or a precingular archeopyle, respectively. *Meiourogonyaulax* Sarjeant in Davey *et al.* 1966a, which has an apical archeopyle, differs from *Spiniferopsis* in lacking processes.

SPECIES (Monotypic)

Type Species:

Spiniferopsis granulata He Cheng-quan 1984a, p. 770, pl. 1, fig. 1. Holotype: pl. 1, fig. 1.

GEOGRAPHIC DISTRIBUTION AND AGE

West Talimu (Tarim) Basin, Xinjiang Province, China; from an imprecisely dated Paleogene (Late Paleocene to Middle Eocene) section.

ORIGINAL DESCRIPTION

"Cysts skolochorate. Body subspherical to ellipsoidal in outline, with solid, isolated processes arising from the points of junctions of sutural ridges, distally simple or branched. Processes arranged basically along cingulum and polar regions, similar to those of the genus *Spiniferites* in distribution, but without intergonal processes. Paratabulation gonyaulacacean, appearing to be ?'(probably 4'), 0-1a, 6", 6c, 5"' (6'"?), ?p, 1"" in formula; paraplate boundaries (including cingulum) indicated by low, smooth sutural ridges and gonal processes. Cingulum clear, relatively narrow, nearly planar or slightly spiral. Shell wall moderately thick (ca. 2.5 μm) and composed of two layers; periphragm surface densely granulate. Archeopyle apical, Type tA, principal suture zigzag; operculum lost". (From He Cheng-quan 1984a, 773).

GENUS *STOMODINIUM* He Cheng-quan 1984a, p. 770 (English translation, p. 774)

SENIOR SYNONYM

Xenicodinium Klement 1960, p. 53-54, synonymy proposed herein.

ORIGINAL DESCRIPTION

"Cysts proximate, acavate. Body subspherical to elliptical in outline, lacking apical and antapical horns. Wall usually very thick; surface with granulation, rugae, tuberculation and a short slender sutural spine. Paratabulation probably gonyaulacacean; paraplates incompletely indicated by sutural features. Cingulum more or less indicated by the alignment of ornamentation or spines in equatorial area. Archeopyle precingular, Type P (3" only). Operculum free but often adherent in situ". (From He Cheng-quan 1984a, p. 774).

COMMENTS

The alignment of surface features is not evident on the illustrated specimens (pl. 1, figs. 12-14), thus the basis for the parasutural features depicted by He Cheng-quan (1984a) on text-fig. 4 is not clear. Without explicit indications of paratabulation, retention of *Stomodinium* as a genus distinct from *Xenicodinium* appears to be unjustified. *Trichodinium* Eisenack and Cookson 1960 emended Clarke and Verdier 1967 differs from *Stomodinium* in the nature of the ornamentation and in possessing an apical horn.

SPECIES (Monotypic)

Reattributed Species:

Stomodinium crassum He Cheng-quan 1984a, p. 770-771, pl. 1, figs. 12-14, text-fig. 2 = *Xenicodinium crassum* (He Cheng-quan) *comb. nov.* Holotype: pl. 1, fig. 12.

GENUS *SUIBINDIA* Yu Jingxian 1982, p. 258-259 (English translation, p. 262)

Figure 9

SYNOPSIS

Cysts proximate, compressed dorso-ventrally, outline ovoidal, narrow end apical; paracingulum planar, archeopyle apical, other indications of paratabulation absent or faintly developed.

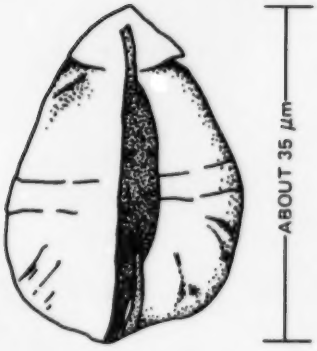


Figure 9. *Suibindia*. Drawing based on specimens illustrated in Yu Jingxian (1982), pl. 8, figs. 12, 23, 25-26.

MODIFIED DESCRIPTION

Shape. Compressed dorso-ventrally, outline ovoidal, apical end narrower than antapical end; a short, small apical horn may be present.

Wall Relationships. Autophragm only.

Wall Features. Surface smooth to scabrate.

Archeopyle. Apical, specific type and operculum unknown.

Paratabulation. Absent or faintly developed.

Paracingulum. Indicated by faint, transverse linear markings; planar.

Parasulcus. A longitudinal, medial fold may represent the parasulcus.

Size. Small, about 25 µm to 45 µm in length, 15 µm to 25 µm in width.

COMPARISON

Suibindia differs from *Escharisphaeridia* Erkmen and Sarjeant 1980 in being compressed dorso-ventrally and in being elongate, and from *Chytroeisphaeridia* (Sarjeant 1962) Downie and Sarjeant 1965 emended Davey 1979 in having an apical rather than a precingular archeopyle.

SPECIES

Type Species:

Suibindia punctata Yu Jingxian 1982, p. 259, pl. 8, figs. 12, 23, text-fig. 4. Holotype: pl. 8, fig. 12.

Other Accepted Species:

Suibindia ovata Yu Jingxian 1982, p. 259, pl. 8, figs. 25-26. Holotype: pl. 8, fig. 26.

GEOGRAPHIC DISTRIBUTION AND AGE

Suibin District, Heilongjiang Province, China; from an imperfectly dated Mesozoic section (Late Jurassic to Early Cretaceous, probably late Kimmeridgian to Berriasian).

ORIGINAL DESCRIPTION

"Cysts dorso-ventrally flattened, their outline ovoid to ellipsoidal, longer than broad, smooth to scabrate having a small apical horn and an apical archeopyle visible in a few samples. Paracingulum annular, on the position of the parasulcus with longitudinal fold, which may correspond to the parasulcus. Paratabulation not indicated". (From Yu Jingxian 1982, p. 262).

GENUS *TETRANGULADINIUM* Yu Jingxian *et al.* 1983, p. 68

ORIGINAL DESCRIPTION (Translation)

Endocyst subspherical to ellipsoidal, enclosed by a periphragm which forms four prominences. Prominences vary in length, membranous-tubular in shape, often with folds parallel to their length. (Translated from Yu Jingxian *et al.* 1983, p. 68).

COMMENTS

According to Yu Jingxian *et al.* (1983) *Tetranguladinium* lacks tabulation and no archeopyle has been observed. They stated, however, that on some specimens a rupture indicates a paracingulum, but the illustrations fail to reveal either a rupture or other features indicative of a paracingulum. In the absence of paratabulation and an archeopyle, we regard this genus as an acritarch. *Tetranguladinium* is probably related to *Sicyoidium* He Cheng-quan 1980, which has a single tubular protrusion, but lacks an inner body.

SPECIES

Type Species:

Tetranguladinium conspicum Yu Jingxian *et al.* 1983, p. 68, pl. 29, fig. 9, pl. 30, figs. 2-6. Holotype: Yu Jingxian *et al.* 1983 did not designate a holotype. Accordingly, we herein designate as the holotype the specimen illustrated in pl. 30, fig. 2 by Yu Jingxian *et al.* (1983).

Other Accepted Species:

Tetranguladinium cruciformis Yu Jingxian *et al.* 1983, p. 69, pl. 29, figs. 6-8; pl. 30, fig. 1. Holotype: Yu Jingxian *et al.* 1983 did not designate a holotype. Accordingly, we herein designate as the holotype the specimen illustrated in pl. 29, fig. 8 by Yu Jingxian *et al.* (1983).

GEOGRAPHIC DISTRIBUTION AND AGE

Jilin Province, China; Late Cretaceous (undifferentiated).

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REFERENCES

Below, R.
1981: Dinoflagellaten-Zysten aus dem oberen Hauterive bis unteren Cenoman Süd-West-Marokkos. Palaeontographica, Abt. B, v. 176, p. 1-145.

Benson, D. G., Jr.
1985: Observations and recommendations on the fossil dinocyst genera *Ctenidodinium*, *Dichadogonyaulax*, and *Korystocysta*. Tulane Studies in Geology and Paleontology, v. 18, p. 145-156.

Brosius, M.
1963: Plankton aus dem nordhessischen Kasseler Meeressand (Oberoligozän). Zeitschrift der Deutschen geologischen Gesellschaft, v. 114, p. 32-56.

Bujak, J. P.
1979: Proposed phylogeny of the dinoflagellates *Rhombodinium* and *Gochtodinium*. Micropaleontology, v. 25, p. 308-324.

Bujak, J. P.
1980: Dinoflagellate cysts and acritarchs from the Eocene Barton Beds of southern England in Bujak, J. P., Downie, C., Eaton, G. L., and Williams, G. L., Dinoflagellate cysts and acritarchs from the Eocene of southern England. The Palaeontological Association, Special Papers in Palaeontology, no. 24, p. 36-91.

Bujak, J. P.
1984: Cenozoic dinoflagellate cysts and acritarchs from the Bering Sea and northern North Pacific, D.S.D.P. Leg 19. Micropaleontology, v. 30, p. 180-212.

Bujak, J. P. and Fisher, M. J.
1976: Dinoflagellate cysts from the Upper Triassic of arctic Canada. Micropaleontology, v. 22, p. 44-70.

Chen, Yow-yuh
1982: Recognition of the dinocyst genus *Komewuia* with assignable species from Madagascar. Micropaleontology, v. 28, p. 31-42.

Clarke, R.F.A. and Verdier, J.-P.
1967: An investigation of microplankton assemblages from the Chalk of the Isle of Wight, England. Verhandelingen der Koninklijke Nederlandsche Akademie van Wetenschappen, Afdeeling Natuurkunde, Eerste Reeks, v. 24, p. 1-96.

Cookson, I. C. and Eisenack, A.
1960a: Microplankton from Australian Cretaceous sediments. Micropaleontology, v. 6, p. 1-18.

Cookson, I. C. and Eisenack, A.
1960b: Upper Mesozoic microplankton from Australia and New Guinea. Palaeontology, v. 2, p. 243-261.

Davey, R. J.
1979: A re-appraisal of the genus *Chytroeisphaeridia* Sarjeant, 1962. Palynology, v. 3, p. 209-218.

Deflandre, G.
1935: Considérations biologiques sur les microorganisms d'origine planctonique conserves dans les silex de la craie. Bulletin biologique de la France et de la Belgique, v. 69, p. 213-244.

Deflandre, G.
1938: Microplancton des mers jurassiques conservé dans les marnes de Villers-sur-Mer (Calvados). Etude liminaire et considérations générales. Travaux de la Station Zoologique de Wimereux, v. 13, p. 147-200.

Deflandre, G.
1947: Sur quelques microorganismes planctoniques des silex Jurassiques. Bulletin de l'Institut océanographique de Monaco, no. 921, p. 1-10.

Downie, C. and Sarjeant, W.A.S.
1965: Bibliography and index of fossil dinoflagellates and acritarchs. Geological Society of America, Memoir 94, p. 1-180 (dated December 1964, appeared January 1965).

Eaton, G. L.
1976: Dinoflagellate cysts from the Bracklesham Beds (Eocene) of the Isle of Wight, southern England. Bulletin of the British Museum (Natural History) Geology, v. 26, p. 227-332.

Eisenack, A.
1958: Mikroplankton aus dem norddeutschen Apt. Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen, v. 106, p. 383-422.

Eisenack, A. and Cookson, I. C.
1960: Microplankton from Australian Lower Cretaceous sediments. Proceedings of the Royal Society of Victoria, v. 72, p. 1-11.

Erkmen, U. and Sarjeant, W.A.S.
1980: Dinoflagellate cysts, acritarchs and tasminitids from the uppermost Callovian of England and Scotland: With a reconsideration of the "*Xanthidium pilosum*" problem. Geobios, no. 13, p. 45-99.

Gocht, H.
1955: *Rhombodinium* und *Dracodinium* zwei neue Dinoflagellaten-Gattungen aus dem norddeutschen Tertiär. Neues Jahrbuch für Geologie und Paläontologie, Monatshefte, p. 84-92.

Grigorovich, A. S.
1969: A new genus *Carpatella* (Dinoflagellata) from Danian-Paleocene deposits of the Carpathians; Paleontologicheskii Sbornik (Collection of paleontological papers) no. 6, p. 74-76 (in Russian with English summary).

Habib, D.
1976: Neocomian dinoflagellate zonation in the western North Atlantic. Micropaleontology, v. 21, p. 373-392.

He Cheng-quan
1980: Some new genera of Oligocene dinoflagellates and acritarchs from the coastal region of Beibu Wan, China. Nanking Institute of Geology and Palaeontology. Academia Sinica, p. 1-11. Paper may not have been effectively published.

He Cheng-quan
1984a: Some new genera of Late Cretaceous to Eocene microphytoplankton from the western Tarim Basin in southern Xinjiang. Acta Palaeontologica Sinica, v. 23, p. 768-774 (in Chinese with English abstract).

He Cheng-quan
1984b: Tertiary dinoflagellates and acritarchs from the coastal region of the Beibu Gulf. Memoirs of the Nanking Institute of Geology and Palaeontology, Academia Sinica, No. 19, p. 143-193 (in Chinese with English abstract).

He Cheng-quan and Qian Ze-shu
1979: Early Tertiary dinoflagellates and acritarchs from the Bose Basin of Guangxi. Acta Palaeontologica Sinica, v. 18, p. 171-188 (in Chinese with English abstract).

Helenes, J.
1983: Evaluation of Jurassic-Cretaceous dinoflagellates in the *Ascodinium-Ovoidinium* complex. Micropaleontology, v. 29, no. 3, p. 255-266, pl. 1.

Jain, K. P. and Millepied, P.
1973: Cretaceous microplankton from Senegal Basin, N.W. Africa. 1. Some new genera species and combinations of dinoflagellates. Palaeobotanist, v. 20, p. 22-32.

Klement, K. W.
1960: Dinoflagellaten und Hystrichosphaerideen aus dem unteren und mittleren Malm Südwestdeutschlands. Palaeontographica, Abt. A, v. 114, p. 1-104.

Krutzsch, W.
1962: Die Mikroflora der Geiseltalbraunkohle. Teil III. Süsswasserdinoflagellaten aus subaquatisch gebildeten Blätterkohlenlagen des mittleren Geiseltales. Hallesches Jahrbuch für mitteldeutsche Erdgeschichte, v. 4, p. 40-45.

Lentin, J. K. and Williams, G. L.
1981: Fossil dinoflagellates: Index to genera and species, 1981 edition. Bedford Institute of Oceanography, Report Series BI-R-81-12, p. 1-345.

Lentin, J. K. and Williams, G. L.
1985: Fossil dinoflagellates: Index to genera and species, 1985 edition. Canadian Technical Report of Hydrography and Ocean Sciences No. 60, p. i-x, 1-451.

Mantell, G. A.
1850: A pictorial atlas of fossil remains consisting of coloured illustrations selected from Parkinson's "Organic remains of a former world," and Artis's "Antediluvian phytology." Henry G. Bohn, London. xii + 207 p.

Mao, Shaozhi
1986: The archeopyle type of *Bohaidina* Jiabo, 1978 and *Parabohaidina* Jiabo 1978. American Association of Stratigraphic Palynologists, Newsletter, v. 19, no. 3, p. 7.

McIntyre, D. J.
1975: Morphologic changes in *Deflandrea* from a Campanian section, District of Mackenzia, N.W.T., Canada. Geoscience and Man, v. 11, p. 61-76.

Morgenroth, P.
1966: Mikrofossilien und Konkretionen des nordwesteuropäischen Untereozäns. Palaeontographica, Abt. B, v. 119, p. 1-53.

Sarjeant, W. A. S.
1961: Microplankton from the Kellaways Rock and Oxford Clay of Yorkshire. Palaeontology, v. 4, p. 90-118.

Sarjeant, W. A. S.
1962: Microplankton from the Ampthill Clay of Melton, south Yorkshire. Palaeontology, v. 5, p. 478-497.

Sarjeant, W. A. S.
1966a: Dinoflagellate cysts with *Gonyaulax*-type tabulation. in Davey, R. J., Downie, C., Sarjeant, W.A.S., and Williams, G. L., Studies on Mesozoic and Cainozoic dinoflagellate cysts; Bulletin of the British Museum (Natural History) Geology, Supplement 3, p. 107-156.

Sarjeant, W. A. S.
1966b: Further dinoflagellate cysts from the Speeton Clay. in Davey, R. J., Downie, C., Sarjeant, W.A.S., and Williams, G. L., Studies on Mesozoic and Cainozoic dinoflagellate cysts. Bulletin of the British Museum (Natural History) Geology, Supplement 3, p. 199-214.

Sarjeant, W. A. S.
1967: The genus *Palaeoperidinium* Deflandre (Dinophyceae). Grana Palynologica, v. 7, p. 243-258.

Sarjeant, W. A. S.
1970: The genus *Spiniferites* Mantell, 1850 (Dinophyceae). Grana Palynologica, v. 10, p. 74-78.

Srivastava, N. S.
1975: A new microsporangiate fructification from the Triassic of Nidin, India. Palaeobotanist, v. 22, p. 19-24.

Stover, L. E., and Evitt, W. R.
1978: Analyses of pre-Pleistocene organic-walled dinoflagellates. Stanford University Publications, Geological Sciences, v. 15, p. 1-300.

Sung Zhi-chen *et al*.
1978: On the Paleogene dinoflagellates and acritarchs from the coastal region of Bohai. p. 1-190, Science Press Beijing (Peking 1978) (In Chinese), edited jointly by the Petrochemical Industry Division, Petroleum Exploration and Development Institute and the Nanking Institute of Geology and Palaeontology.

Wall, D.
1967: Fossil microplankton in deep-sea cores from the Caribbean Sea. Palaeontology, v. 10, p. 95-123, pl. 14-16.

Wiggins, V. D.
1975: The dinoflagellate family Pareodiniaceae: A discussion. Geoscience and Man, 11:95-115.

Yu Jingxian
1982: Late Jurassic and Early Cretaceous dinoflagellate assemblages of eastern Heilongjian Province, China. Bulletin of the Shenyang Institute of Geology and Mineral Resources, Chinese Academy of Geological Sciences, no. 5, p. 227-267 (in Chinese with English abstract).

Yu Jingxian, Guo Zhengying and Mao Shaozhi
1983: Cretaceous palynological assemblages from the district south of the Songhua River. Memoirs of Stratigraphic Paleontology no. 10, edited by the Chinese Academy of Geological Sciences, Stratigraphic Paleontology Committee, Geological Publications House, Beijing (Peking) p. 1-86. Cited in text as Yu Jingxian *et al*. 1983.

Yu Jingxian, Sun Mongrong, Sun Suying and Mao Shaozhi
1981: Dinoflagellates and acritarchs from the Dalanshan Formation and their significance in explaining the depositional environment (English Title). Oil and Gas Geology, v. 2, p. 254-264 (in Chinese with English abstract). Late Cretaceous dinoflagellates and acritarchs from the Sanshui Basin, Guangdong Province (Chinese Title). Cited in text as Yu Jingxian *et al.* 1981.

Yu Jingxian and Zhang Wangping
1980: Upper Cretaceous dinoflagellate cysts and acritarchs of western Xingiang. Bulletin Chinese Academy of Geological Sciences, Series 1, v. 2, p. 93-119 (in Chinese with English abstract).